DOCUMENT RESUME

ED 187 533 SE 030 745

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TITLE The Effects of Diagnostic/Remedial Instruction on Science Learning: A Meta-Analysis.
PUB DATE Apr 80
NOTE 14p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (53rd, Boston, MA, April 11-13, 1980).

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; *Diagnostic Teaching; Educational Research; Higher Education; Literature Reviews; *Research Reports; Science Education; Science Instruction; Secondary Education; *Statistical Analysis
IDENTIFIERS *Meta Analysis

ABSTRACT

Experimental studies based on diagnostic prescriptive instruction, as it affects science achievement of college, high school, and middle school students, were analyzed statistically by the procedure of meta-analysis to determine the effectiveness of this instructional treatment. "Effect size" was calculated on each of 30 dependent variables. Data were organized by categorizing all treatments into one of three types: (1) Control, no diagnosis and no prescription; (2) Treatment I, diagnosis and no prescription; and (3) Treatment II, diagnosis and prescription or remediation. This yielded a total of 21 Treatment I and 32 Treatment II effect sizes. A mean effect size was then calculated for each treatment. Results of meta-analysis indicate that diagnostic prescriptive instruction significantly and positively influences science achievement. However, there is no clear indication that the use of prescription or remediation in addition to diagnosis brings about a significant increase in achievement. (Author/CS)

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THE EFFECTS OF DIAGNOSTIC/REMEDIAL INSTRUCTION ON SCIENCE LEARNING: A META-ANALYSIS

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A Paper Presented
at the
Annual Meeting of the
National Association for Research in Science Teaching

Boston, MA

April, 1980

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THE EFFECTS OF DIAGNOSTIC/REMEDIAL INSTRUCTION ON SCIENCE LEARNING: A META-ANALYSIS

Since Bloom (1968) emphasized the importance of learning diagnosis with feedback and prescribed remediation, numerous experimental studies related to the learning of science have been reported in this area. The generic components of a diagnostic/remedial instructional system have been defined by Okey (1974) as follows:

Step 1: Specify performance objectives;

Step 2: Develop diagnostic measures for objectives:

Step 3: Teach using any preferred procedures;

Step 4: Test achievement of objectives using diagnostic measures;

Step 5: Remediate and rediagnose, if desired; and,

Step 6: Administer summative test.

As should be expected, the research related to diagnostic remedial instruction and science achievement has varied both in the specific nature of the treatments and the results. Some studies have focused on the effects of providing students with diagnosis and feedback with no prescribed remediation (e.g., Yeany, Waugh & Blalock, 1979). In other studies, a treatment which involved both diagnosis and remediation was examined (e.g., Lueckemeyer & Chiappetta, 1979); and, in still others, multiple treatment levels of no diagnosis, diagnosis only, and diagnosis with remediation were included (e.g., Saunders & Yeany, 1979). The dependent variable of main interest was usually science fact, concept or skill learning with attitude of student given secondary or no consideration.

The results of such studies usually favored some form of diagnostic feedback, prescribed remediation or both. But, some researchers reported no impact resulting from such instruction (e.g., Cain, 1980) while others found significant differences in some units of instruction and not in others (e.g., Benson & Yeany, 1980).

PURPOSE

Because of the variations in methods and results of studies examining the effects of diagnostic-remedial instruction on science learning, an integrating analysis of the studies and their results is called for. Glass (1976) suggested that there is a need for a type of integrating research which uses previous findings in a particular area as the unit of analysis. He argued that:

> "In educational research, we need more scholarly effort concentrated on the problem of finding the knowledge that lies untapped in completed research studies....This endeavor deserves higher priority now than adding a new experiment or survey to the pile."

Glass (1978) defined a process for statistically integrating the findings of a set of studies and labeled it meta-analysis (analysis of analyses).

In the present study, meta-analysis procedures were employed to integrate existing science education research findings on the effectiveness of diagnostic/remedial instruction to:

a) determine the magnitude of effect that can be expected from diagnostic remedial instruction;

b) to determine and compare the relative magnitude of effects attributable to different components of the method (i.e., diagnosis only versus diagnosis with prescribed remediation);

c) to examine the relationship between the effect and school level of the student (i.e., middle and high school versus college); and,

d) to examine the relationship between the effect and the number of occasions that the students experienced a summative test within the study period.

PROCEDURES

Computer and library literature search procedures were used to locate 28 documents for which the title or descriptors suggested that they pertained to diagnostic/remedial instruction in science. In order for a study to be retained for inclusion in the meta-analysis, the following criteria had to be met:

a) treatment had to include at least the diagnostic testing component of the diagnostic/remedial instruction strategy;

b) the content focus of the instruction was aimed at science achievement or attitudes; and,

c) enough statistical data had to be given or be available from the author to derive effect sizes for the treatments examined in the study.

To facilitate the integration of the findings, diagnostic/remedial treatments were classified into one of three categories. Those which provided no diagnosis and no remediation were classified as Type I or contrast treatment. Interventions which included achievement diagnosis with feedback only (no prescribed remediation) were classified as Type II treatments. Diagnosis was defined as an assessment of a student's progress related to a specific set of instructional goals and occurs before the summative measure of those goals. Treatments which provided diagnosis and prescribed remediation were labeled as Type III treatments. In this case, prescribed remediation included any instructional assistance or guidance provided to a student for strengthening learning weaknesses revealed by the diagnosis. Prescriptions included assignment of remediation materials and/or activities, and individualized assistance. Management responsibilities ranged from self or peer to teacher. In Figure 1, the treatment types have been positioned on a model (from Yeany, Dost & Matthews, 1980) which depicts the relationship of the components of diagnostic/remedial instruction.

(Insert Figure 1 About Here)

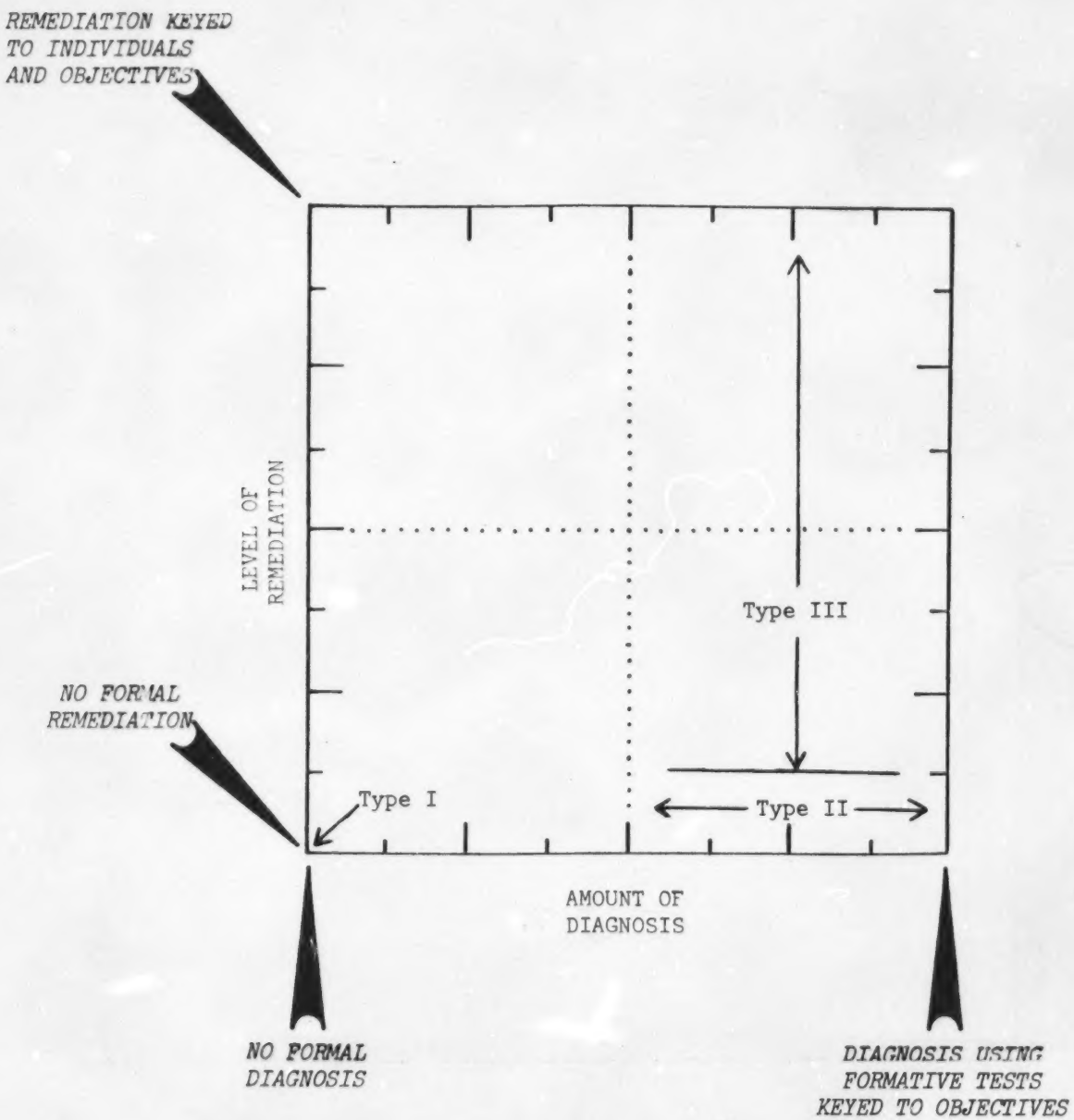

Figure 1. A diagnostic/remedial activities model. Coordinates in each of the quadrants represent the nature of a specific D/R system (from Yeany, Dost & Matthews, 1980).

To determine the impact of treatment, the recommended procedure in a meta-analysis is to calculate an "effect size" which is defined as the difference between a baseline mean (e.g., control group) and the treatment group mean in units equal to the standard deviation of the baseline data. In this case:

$$ES = \frac{\bar{X}_E - \bar{X}_C}{S_{X_C}} .$$

Where one or more of the needed statistics was not reported, the needed information was derived from other reported statistics. For example,

$$S_X = \sqrt{\frac{MS_b}{F}} \qquad \text{and} \qquad ES = t\sqrt{\frac{1}{n} + \frac{1}{n}} .$$

In some cases, the author was contacted to supply the required data. Mean effect sizes ($\overline{ES}$) were calculated for the Type II and Type III treatments by comparing the treatment group results with a control within the same study and then averaging across all the effect sizes for a particular class of treatment. Where more than one achievement measure was employed (e.g., immediate and retained achievement), an effect size was calculated for each. Thus the unit of analysis in this meta-analysis is the finding and not the study. A separate effect size for attitude changes was calculated.

In order to assess the relationship of the impact of diagnostic/remedial instruction to school level and number of occasions that the students experienced a summative test, an R^2 for each of the possible relationships was calculated.

FINDINGS

As can be noted in Table 1, the impact of the two treatment types on science achievement is essentially equal. On the basis of different

effect sizes for diagnosis with feedback (Type II), the mean effect was $\overline{ES}$ = .49, and on the basis of 49 effect sizes, diagnosis followed by prescribed remediation (Type III) lead to an $\overline{ES}$ = .55. The confidence intervals associated with each of these values show them to be significantly different from zero ($p < .05$) but not significantly different from each other. Only seven (10%) of the 68 effect sizes were negative. It should be assumed that if the treatments were neutral, one-half of the effect sizes would be negative.

(Insert Table 1 About Here)

The impact of treatment can also be defined in terms of the median treated person's percentile status in the control group distribution; these values were 69%ile and 71%ile for Type II and III treatments respectively. Figure 2 graphically represents these results assuming an underlying normal distribution of effect sizes.

(Insert Figure 2 About Here)

In relation to effect on the attitude, data were only available from studies which investigated Type III treatments. Attitudes measured by the various studies included attitude toward science, instruction, or both. As can be seen from Table 2, there does not appear to be much attitudinal difference resulting from diagnostic/remedial instruction.

In an attempt to assess the generalizability of the findings, the research reports were divided into college and pre-college studies and analyzed for a relationship between effect size and school level. On the basis of 68 different effect sizes, no relationship appears to exist ($p > .05$) (see Table 3)

(Insert Table 2 & 3 About Here)

TABLE 1

Summary of Effect Size Calculations on the Impact of Diagnostic/Remedial Instruction on Science Achievement

	TYPE OF INSTRUCTION	
	Type II DIAGNOSTIC FEEDBACK ONLY	Type III DIAGNOSTIC FEEDBACK AND REMEDIATION
$\overline{ES}$	.49 ± .12	.55 ± .07
S^2_{ES}	.22	.22
S_{ES}	.47	.47
$S_{\overline{ES}}$	.12*	.07*
%ile of control	69th	71st
Min ES	-.11	-.25
Max ES	1.99	1.93
n	19	49
n+	16 (84%)	45 (92%)
n-	3 (16%)	4 (8%)

*$S_{\overline{ES}}$ should be interpreted as a lower bound because of the dependency of ES's originating from the same study

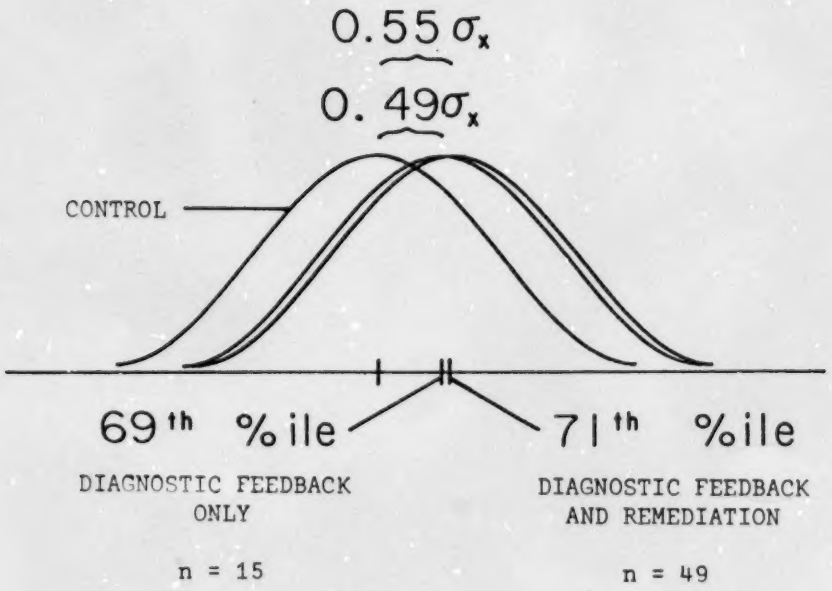

Figure 2. Effects of diagnostic feedback and diagnostic feedback with remediation on science achievement.

TABLE 2

Summary of Effect Size Calculations on the Impact of Diagnostic/Remedial Instruction* on Attitudes in Science

$\overline{ES}$	.18 ± .08
S^2_{ES}	.076
S_{ES}	.276
$S_{\overline{ES}}$	.08
%ile of control	57th
Min ES	-.26
Max ES	.627
n	11
n+	8 (73%)
n-	3 (27%)

*No comparative results were reported for Diagnostic Feedback Only (Type II) treatments

TABLE 3

Correlations of Two Descriptive Variables with Effect Size

Variable	n	r	R^2	p
Number of summative tests experienced by subjects	57	-.08	.001	>.10
School level (Middle and high school vs college)	68	.21	.04	>.05

An hypothesis suggested by recent studies (Yeany et al, 1979; Benson et al, 1980) was that the impact of diagnostic/remedial science instruction increased as students continued to experience the conditions and learn how to make best use of the feedback and/or remediation. This hypothesis was not supported by the integrated findings ($p > .10$) (see Table 3).

CONCLUSIONS

On the basis of the available research findings, it appears that achievement can be significantly and positively influenced through diagnostic/remedial instruction. The magnitude of this influence can be expected to be about .55 standard deviation units of achievement when compared to an instructional strategy which does not employ diagnosis and remediation. The surprising result in this study is the source of the impact. It does not appear to be the remediation but rather the diagnostic feedback. The test practice might account for some of this gain (most researchers were quite careful to point out that the diagnostic and summative tests were parallel but different), but not for all of it. One must conclude that science students are capable, in the absence of prescribed remedial activities, to attend to their own remediation when provided with feedback from the diagnosis of achievement deficits.

Although surprising, these results are encouraging. Providing only diagnostic feedback to the science student is far simpler and less demanding than following with complex remediation schedules and cycles. Science instruction may be improved with less additional teacher effort than has been suggested in reports of studies involving treatments consisting of both diagnosis and teacher prescribed remediation.

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